The Economic Foundations of the Ohio River Navigation Investment Model (ORNIM)

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Presented at the

Economic and Environmental Analysis Conference

April 13-15 2004

What is ORNIM?

- **A spatially-detailed partial equilibrium model**
- **Built by ORNL in collaboration with the Navigation Planning Center, Great Lakes and Ohio River Division**
- **Estimates net benefits of river system improvements—e.g., new locks, component replacements, maintenance policies—and balances benefits against costs**

Objectives of this Paper

- **Identify the economic assumptions made within ORNIM**
- **Provide the rationale for these assumptions**
- **Assess how these assumption alter estimates of inland-waterway navigation benefits and costs as compared to the theoretical ideal**
- **Suggest improvements to move toward theoretical ideal and provide most accurate and useful information to decision makers**

ORNIM Must Be Consistent with…

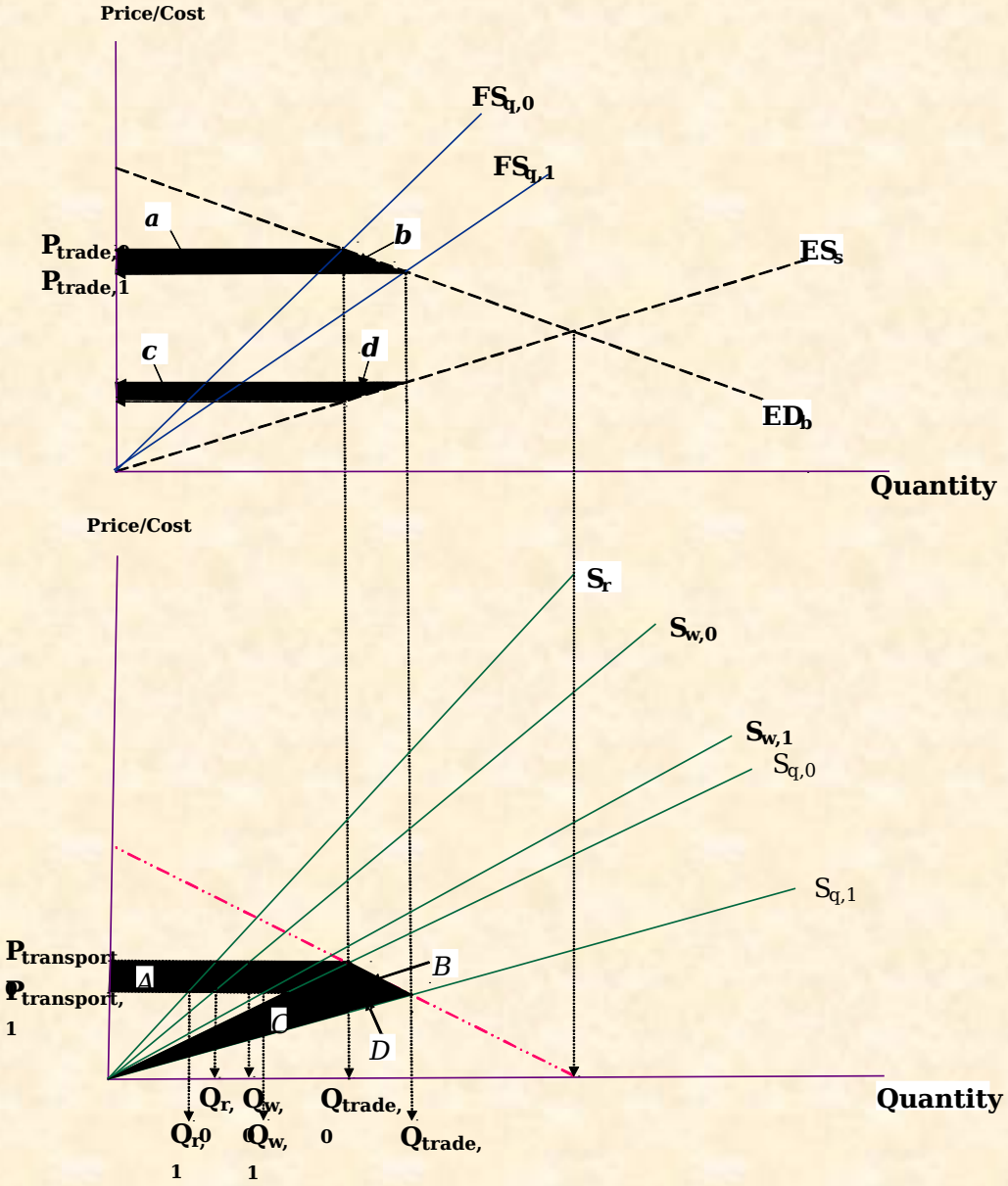
- **Principles and Guidelines**
- **Data availability**
- **Computational limits**
- **Analysis budget constraints**
- **A philosophy of providing conservative benefit estimates**

A Key Limitation of ORNIM

- **Appropriate to assess benefits of relatively small infrastructure improvements**
- **Not appropriate to estimate total benefits of the Ohio River System**

Conceptual Spatially Detailed Partial Equilibrium Models

- **Derived demand for freight transport**
- **Supply of freight transport**
- **Derived demand for water transport**
- **Measuring without-project benefits**
- **Measuring with-project benefits**
- **Benefits measured as gains in producer and consumer surplus**


Price/Cost
FS_q,0
FS_q,1
a
b
P_trade,0
P_trade,1
ES_s
c
d
ED_b
Quantity
Price/Cost
S_r
S_w,0
S_w,1
S_q,0
S_q,1
P_transport,0
P_transport,1
A
B
C
D
Q_r,0
Q_r,1
Q_w,0
Q_w,1
Q_trade,0
Q_trade,1
Quantity

Three basic questions

1. **How much congestion costs are shippers willing to pa**

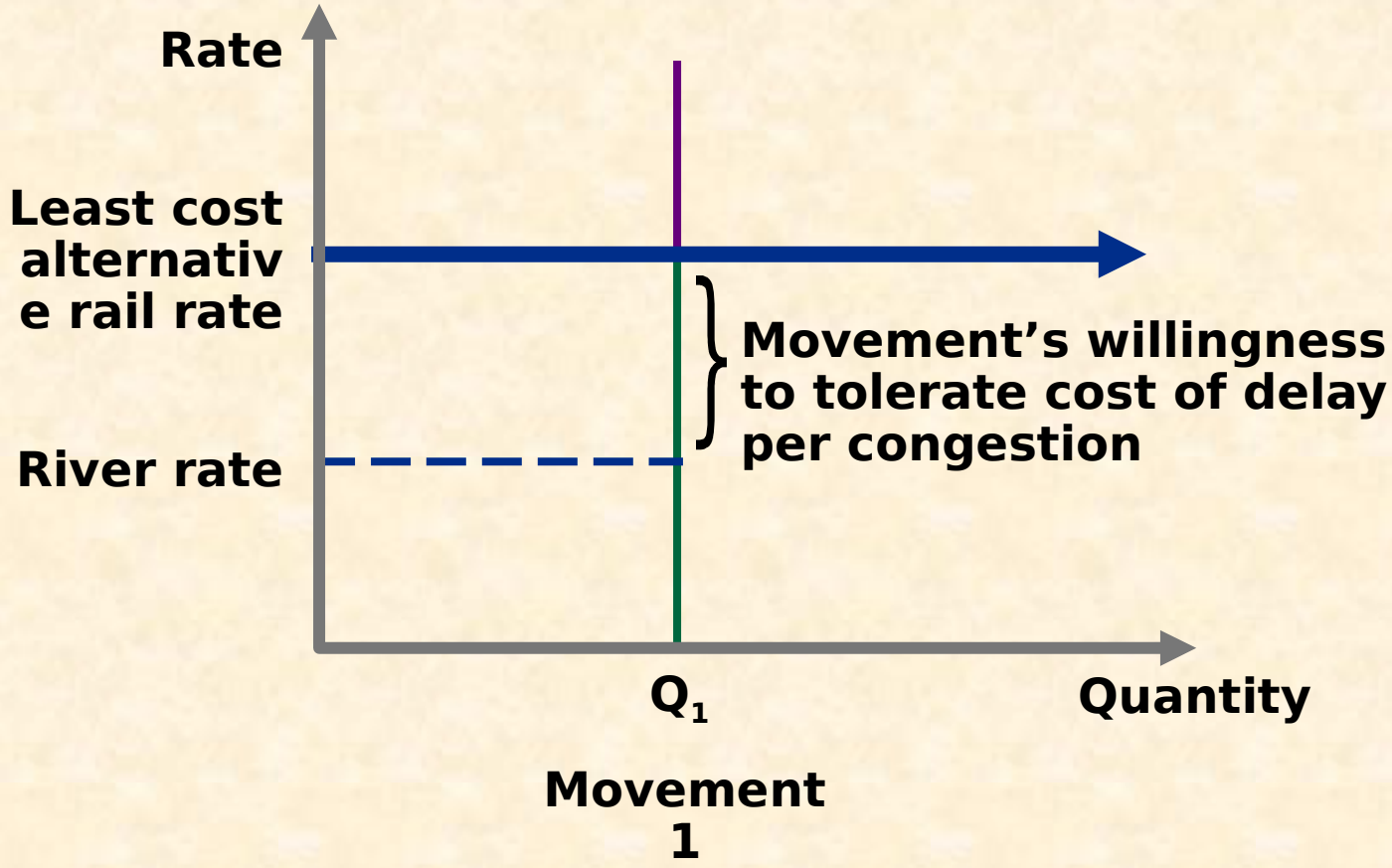
2. **Will shippers move part of their movements to alternative modes as the cost of congestion increases?**

3. **Is it appropriate to assume that any and all quantities of freight can be moved from river to rail with no impacts on rail capacity and rail rates?**

Three Critical Economic Assumptions

- **The demand for individual movements is provided exogenously and is perfectly inelastic with respect to the price of river transport**
- **The willingness-to-pay for individual movements on the river is equal to the least-cost alternative rail rate, which is provided exogenously**
- **The supply of rail for individual movements is perfectly elastic at the given rail rate**

ORNIM models individual movements and places movements on the river up to the point where the cost of delay exceeds the OD's willingness-to-pay



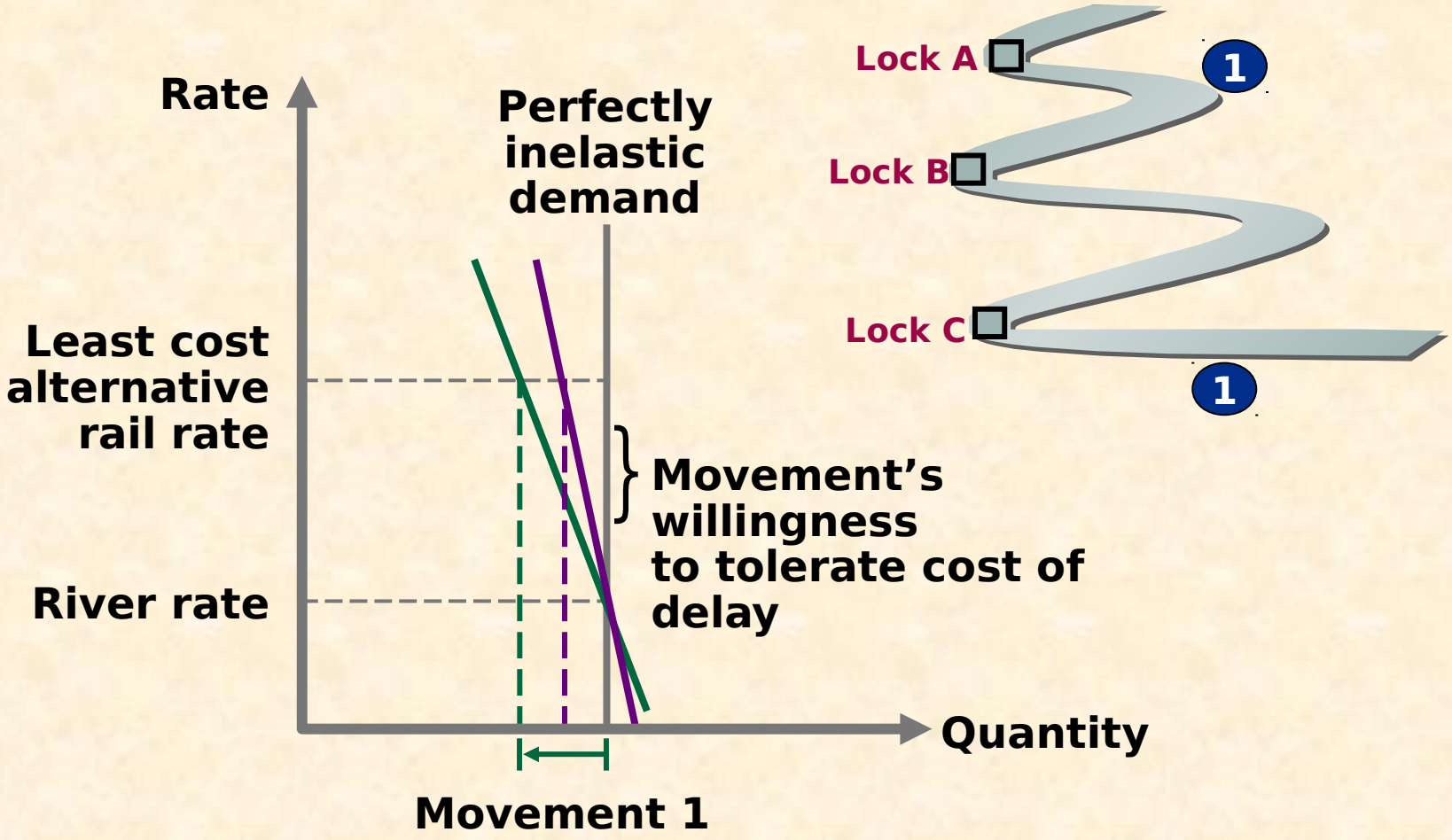
Assumption: Demand for Individual Movements is Perfectly Inelastic and Willingness-to-Pay is Equal to Least Cost Rail Alternative

- **Motivation**
  - **Very reasonable in short run**
  - **Long run more interesting**
    - **Bray Study**
    - **Long run decisions depend on numerous factors, of which river rates are one**
    - **Data requirements needed at the OD level**
    - **Demand scenarios vs. demand elasticity??**
- **Induced demand not modeled**

Assumption: Demand for Individual Movements is Perfectly Inelastic and Willingness-to-Pay is Equal to Least Cost Rail Alternative

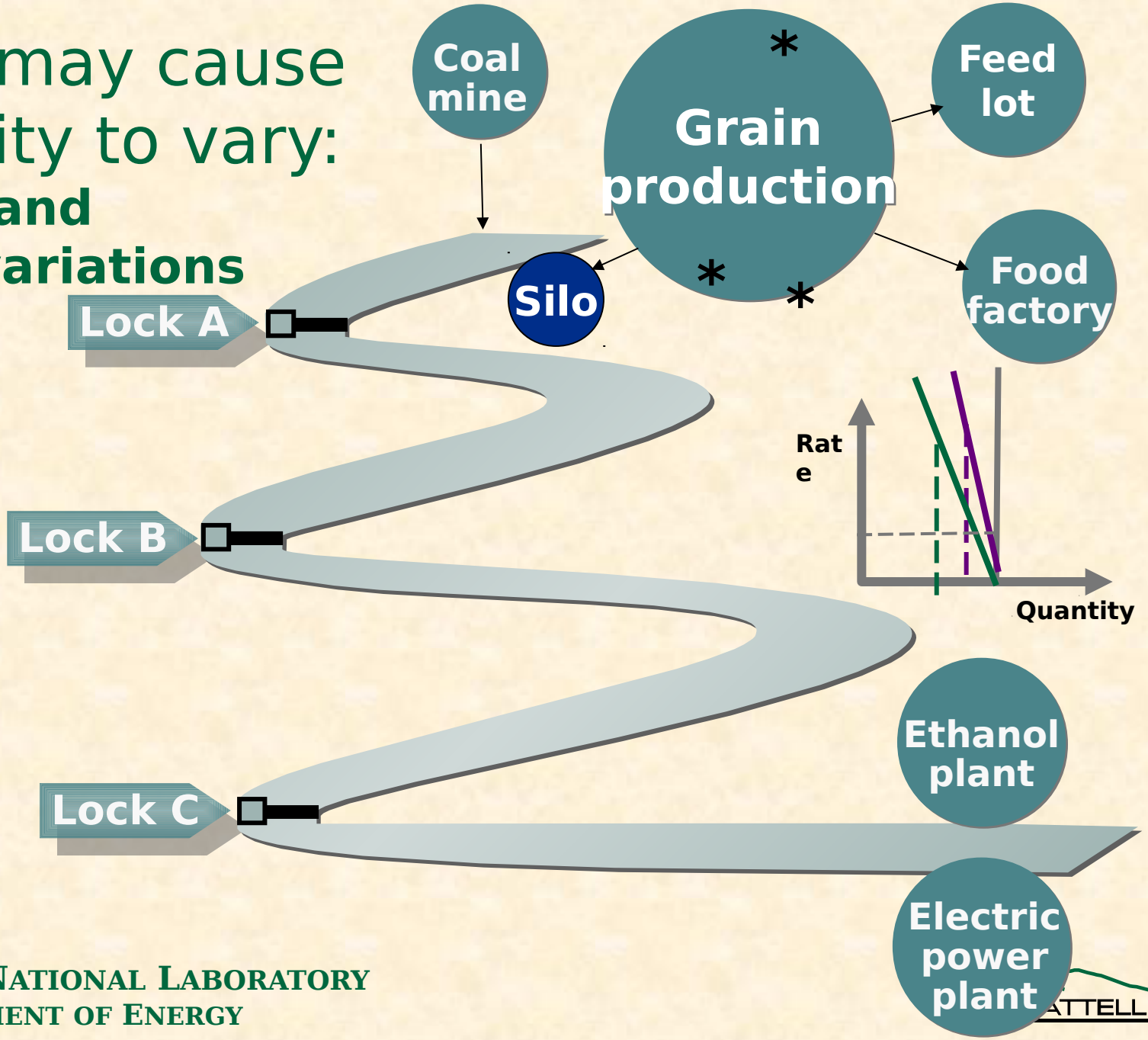
- **Implications**
  - **Perfectly inelastic demand imposes upward bias on navigation benefits**
  - **Willingness-to-pay bias is an empirical question**
  - **The combination of the two assumptions imposes an uncertain bias – becomes an empirical question**
- **Implementing elasticity will be an arduous task, requiring elasticity data at the OD level**
- **Importance may vary by river system and commodities shipped on the river system**

Analysts debate the elasticity of demand for individual movements

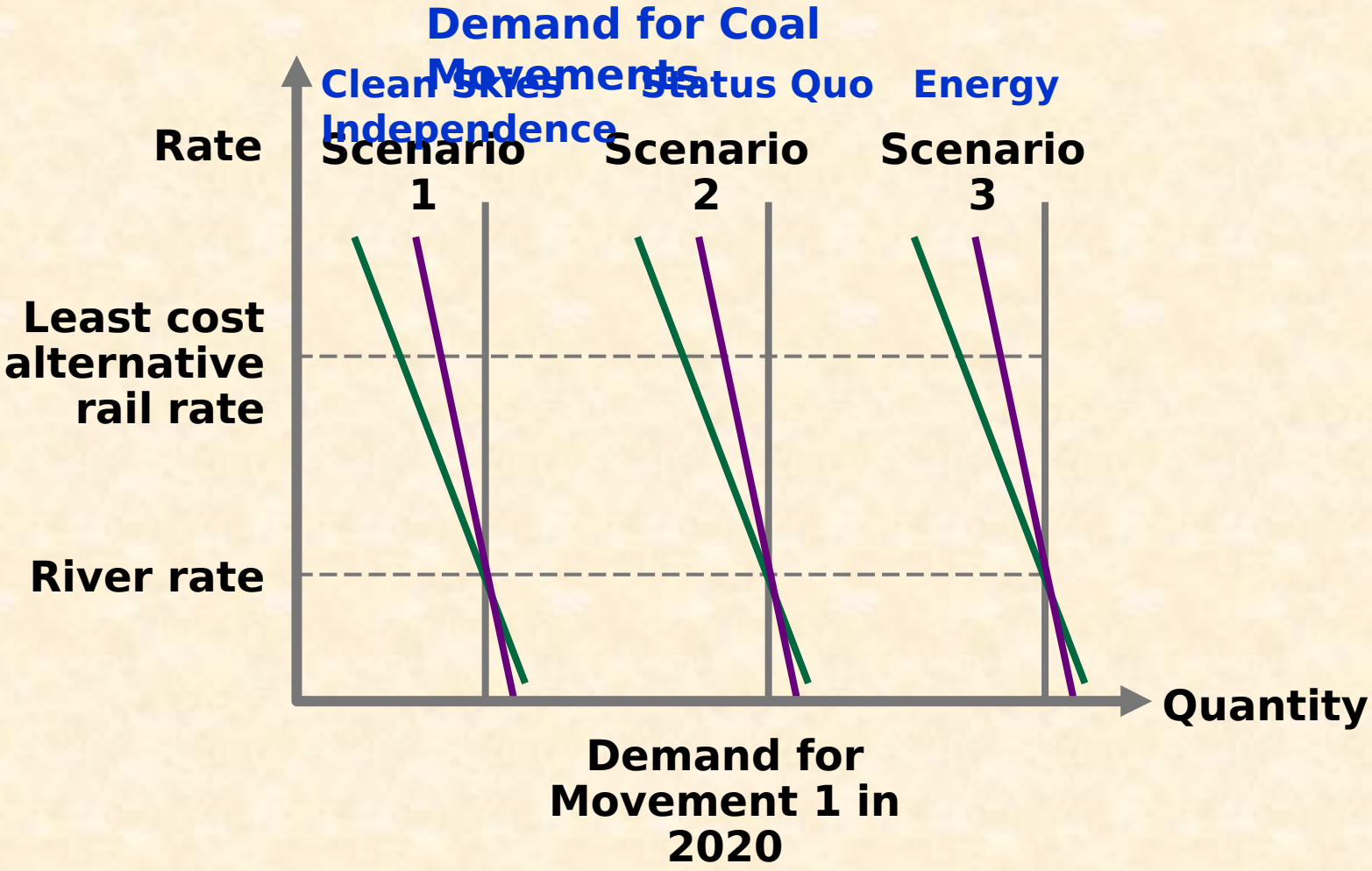


What may cause elasticity to vary:

Spatial and sector variations



Is a focus on scenarios more important and relevant to decision making?



Assumption: The Supply of Rail Is Perfectly Elastic at the Exogenously Given Rail Rate

- **Motivation**
  - **River transport about 5% of total U.S. freight, but varies significantly by commodity and region**
  - **Excess rail capacity varies by region**
  - **Some regions experience tight rail supply**
  - **Multi-modal modeling not currently practiced within the Corps**

Assumption: The Supply of Rail Is Perfectly Elastic at the Exogenously Given Rail Rate

- **Implications**
  - **Unequivocally biases estimate of with-project benefits downward**
  - **Increased river capacity will drive down transport prices for other modes – i.e., induced rail rates – not included in ORNIM**

Spatial Detail and Equilibrium

- **ORNIM considers some 8,000 annual movements covering 9 commodity types**
- **Significant spatial detail**
- **Point-to-point costs (land and water) are estimated via an engineering cost model**

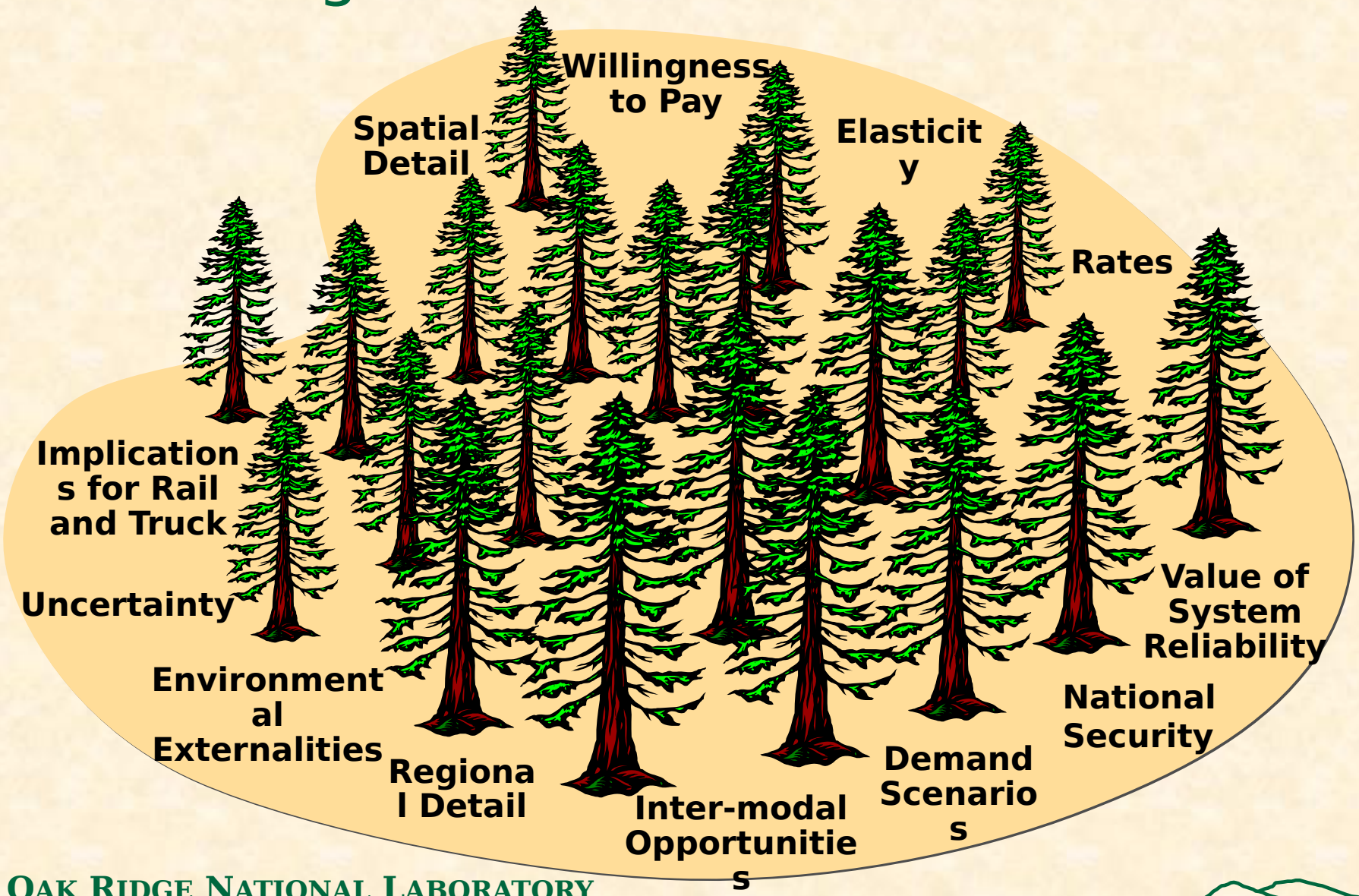
Spatial Detail and Equilibrium (cont.)

- **ORNIM assigns marginal movements via an iterative process based on Wardrop's First Principle**
- **At equilibrium, marginal movements assigned by ORNIM to the river system have a positive saving, movements assigned to land would have a negative savings if left on the river, and movements that have their tonnage split between land and water have zero savings**

Potential Market Failures May Bias Benefit Estimates

- **Congestion externalities**
  - **Congestion fees**
- **Public goods**
- **Environmental, health, infrastructure damages**
- **Information and uncertainty**
  - **Traffic Scheduling**
  - **Nonstructural Measures**

Modeling: The Forest and the Trees



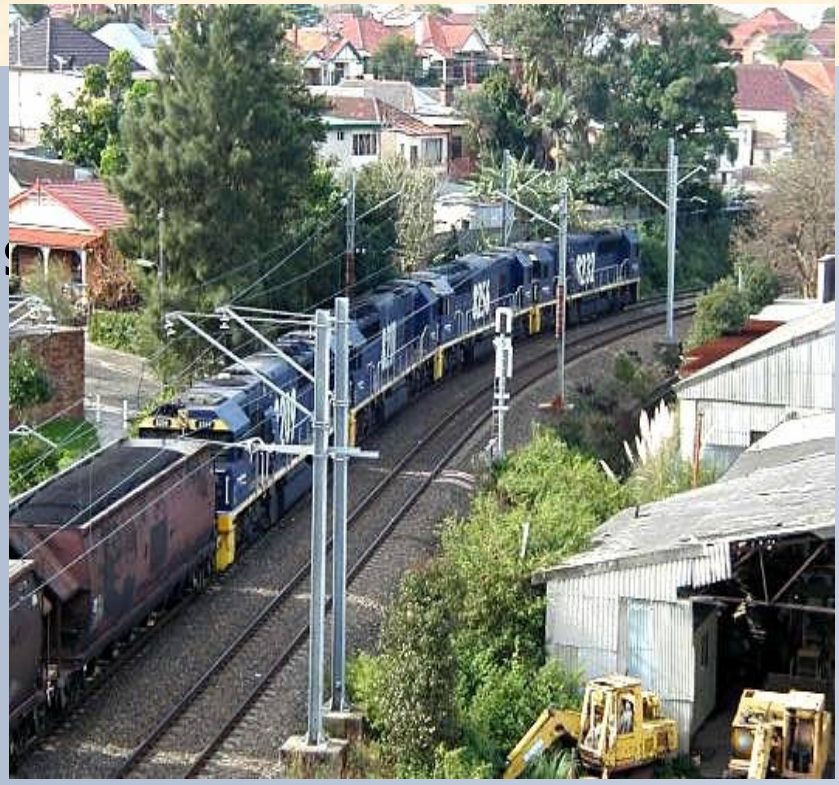
Navigation benefits not considered
(continued)

- **Benefits of System Reliability are underestimated**
  - **An unreliable system will lead to unplanned closures**
  - **The costs of planned and unplanned closures are not distinguished in current models**
  - **Unplanned closures impose costs over and above planned closures**

Navigation benefits not considered
(continued)

Externalities

- **Environmental damages**
  - **Air Pollution**
  - **Visibility**
  - **Global Warming**
- **Human health**
  - **Accidents**
  - **Pollution**
  - **Occupational Injuries**



Navigation benefits not considered
(continued)

Congestion

- **Highway Delays**
- **Safety Impacts from Diverted Overland Movements**

Transportation Infrastructure

- **Damage to Roads and Bridges**

Conclusions

- **ORNIM based on sound economic theory**
- **Assumptions motivated by real-world conditions**
- **Assumptions lead to both positive and negative bias in estimation of benefits**
- **Care taken to be conservative in benefit estimation**
- **Relaxing major assumptions limited by data**
- **Relaxing assumptions will require focus on individual ODs and inter-modal detail**

Conclusions (continued)

- **ORNIM can be improved to be more consistent with economic theory**
  - **Congestion externalities**
  - **Externalities – environmental, health, etc.**
  - **Uncertainty**
  - **Multimodal considerations**
  - **Available resources should be targeted carefully to provide the decision maker with the best possible information**